Impact of the effect of economic crisis and the targeted motorcycle safety programme on motorcycle-related accidents, injuries and fatalities in Malaysia

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In 1997, a Motorcycle Safety Programme (MSP) was introduced to address the motorcycle-related accident problem. The MSP was specifically targeted at motorcyclists. In addition to the MSP, the recent economic recession has significantly contributed to a reduction of traffic-related incidents. This paper examines the effects of the recent economic crisis and the MSP on motorcycle-related accidents, casualties and fatalities in Malaysia. The autocorrelation integrated moving average model with transfer function was used to evaluate the overall effects of the interventions. The variables used in developing the model were gross domestic product and MSPs. The analysis found a 25% reduction in the number of motorcycle-related accidents, a 27% reduction in motorcycle casualties and a 38% reduction in motorcycle fatalities after the implementation of MSP. Findings indicate that the MSP has been one of the effective measures in reducing motorcycle safety problems in Malaysia. Apart from that, the performance of the country's economy was also found to be significant in explaining the number of motorcycle-related accidents, casualties and fatalities in Malaysia.

Keywords: Motorcycle Safety Programme; Gross domestic product; Autocorrelation integrated moving average model; Transfer function model.

1. Introduction

The motorcycle is the predominant mode of transport for the masses in Malaysia. It accounts for over 50% of all traffic distributions on Malaysia roads. In line with the transport policy, motorcycles play a key role in ensuring sustainable mobility for the masses, due to their low operating costs. For the last decade or so, the number of registered motorcycles has increased tremendously, from 1556 516 motorcycles in 1976 to 5609 351 motorcycles in 2001 (figure 1). Subsequently, motorcycle-related fatalities have been increasing dramatically since 1988 (figure 2).

Since then, a number of efforts have been made to reduce these motorcycle problems. Among the efforts carried out were: (i) improvements in road conditions; (ii) emphasis on behaviour modification; and (iii) intensive traffic enforcement. In 1997, a Motorcycle Safety Programme (MSP) was introduced to address motorcycle-related accidents, which incorporated the efforts mentioned above and the programme was officially launched by the Prime Minister of Malaysia. The MSP was specifically targeted at motorcyclists. This long-term programme was aimed at modifying road user attitudes and behaviour on identified motorcycle safety issues (Radin Umar 1999), such as proper use of helmet, lack of conspicuity and excessive speeding, in addition to earlier interventions, which introduced more exclusive motorcycle lanes (Radin Umar *et al.* 1995, 2000) road safety auditing and selective enforcement.

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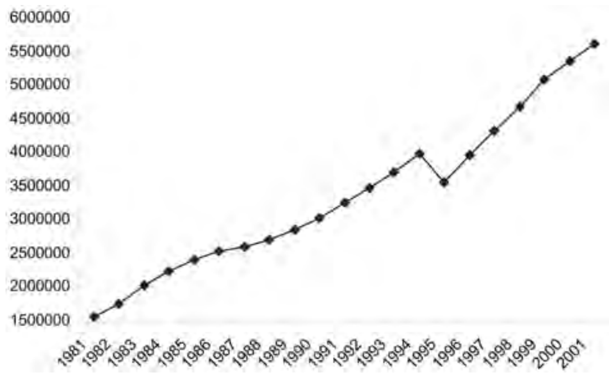

Figure 1. Number of registered motorcycles in Malaysia, 1981 – 2001.

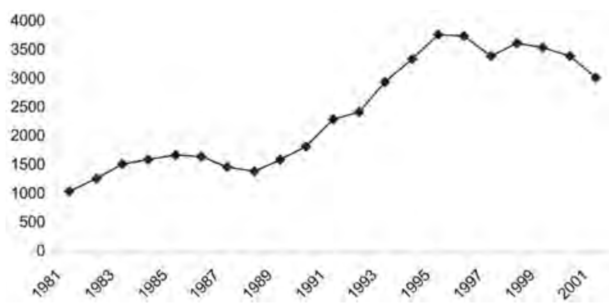

Figure 2. Motorcycle-related fatalities, 1981 – 2001.

Since 1998, traffic safety in Malaysia has improved considerably, whereas in 1998 itself the motorcycle-related fatality figures declined marginally for the first time in almost 10 years despite the increasing number of registered motorcycles (figure 2). Subsequently, in 2001, this number fell to 3034 cases.

In addition to the enactment of the MSP, the recent economic recession has significantly contributed to a reduction in traffic fatalities. This could be due to fewer trips generated resulting from slow economic activity, which in turn reduced the traffic exposures. This phenomenon is supported by Walker (1996) and (Hoxie *et al.* 1984), who pointed out that economic recession has an impact on fatality rates due to changes in travel patterns. As such, the effects of these factors in explaining motorcycle-related accident trends are worthy of further investigation. Gross domestic product (GDP) per capita is used as a proxy for income (the average value of production per person). Previous researchers have noted that indicators of income reflect economic conditions and have significant impact on crash frequency (Hakim *et al.* 1991, Ruhm 1995, Scuffham and Langley 2002).

This paper examines the effects of both the motorcycle safety intervention (MSP) as well as the economic crisis on motorcycle-related accidents, injuries and fatalities in Malaysia.

2. Methodology

2.1. *Design and analysis plan*

The Time Series Quasi-experimental design (Campbell and Stanley 1966, Cook and Campbell 1979) was adopted to assess the impact of MSP and economy recession on the number of motorcycle-related accidents, injuries and fatalities. This design involved an examination of outcome series over a period of time, which was hypothesized to be interrupted by interventions and utilization of comparison time series that was expected not to be affected. In this study motorcycle-related accident events (motorcycle-related accidents, fatalities and casualties) are used as outcome series, while non-motorcycle-related events (non-motorcycle-related accidents, fatalities and casualties) are used as comparison time series.

This design divided the time series into two segments, namely, pre-intervention and post-intervention. Intervention impact was tested by comparing the pre- and post-intervention segments of time series. This analysis approach uses both the pre-programme baselines in the outcome series as a source for the no-treatment expectation outcome and the matched comparison series as controls for 'history' threats to internal validity. The interrupted time-series design for each matched pair comparison can be diagrammed as:

Outcome series O O O O O X X X X X

Comparison series O O O O O O O O O O

Here each O denotes observations on the dependent variable, while X denotes a discrete intervention. Multiple observations provide data sufficient to determine the natural (historical) pattern of the time series, such that secular trends in the outcomes are not confused with the effect of the interventions. In addition, the use of identical measurements from a comparison series provides protection against the effect of confounding factors, such as economic crisis and new transport policy.

2.2. *Data sources*

Annual statistic figures of motorcycle-related and non-motorcycle-related accidents, injuries and fatalities for 29 years from 1973 to 2001 were obtained from Traffic Police headquarters. This information was based on motor vehicle traffic accident reports received from local police jurisdictions. This time series provides 25 pre-intervention and four post-intervention observations.

Meanwhile, the GDP index was obtained from the Central Bank of Malaysia for the study period. This parameter was used as an explanatory variable in explain-

ing the effects of the economic downturn currently faced by the country.

2.3. *Autocorrelation integrated moving average model and transfer function analysis*

Data observed over a period of time is usually autocorrelated with a tendency for measurements made close together in time to be more alike than those taken farther apart. Therefore, the ordinary regression method, such as linear regression, negative binomial and poisson model, are not appropriate for this analysis because these methods assume that the data observed over a period of time are independent (Wagenaar 1983, Lewis-Beck 1986). Skinner (1988) found that due to the high correlation between many observations, complicating the regression model with many variables does not improve regression model adequacy significantly.

In light of the problem associated with ordinary methods, it was more suitable to use time series regression, such as the autocorrelation integrated moving average (ARIMA) model as a means to better predict accident outcomes over a period of time (Box and Jenkins 1976). The ARIMA model is a statistical method for analysing longitudinal data with correlation among neighbouring observations.

In ARIMA analysis, there are two simple components for representing the behaviour of observed time series processes, namely, the autoregressive (AR) and moving average (MA) models. The AR model is used to describe a time series in which the current observation depends on its preceding values, whereas the MA model is used to describe a time series process as a linear function of current and previous random errors. It is possible that a stationary time series will consist of a mixture of AR and MA components. In this case the series are said to be computed by an AR MA process of order (p,q), where p and q are the orders of the AR and MA components, respectively. The selection strategy for such models was developed and selected by Box and Jenkins (1976). A general ARIMA model can be written as:

$$B^d N_t = \frac{\theta(B)a_t}{\phi(B)} \quad (1)$$

where a_t is assumed to have white noise, B is the backshift operator, N represents stochastic part, d is the order of regular differencing needed to achieve time series stationarity and other parameters in the model are defined as follows:

$$\theta_q(B) = 1 - \theta_1 - \theta_2 B^2 - ... - \theta_q B^q, \quad (2)$$

$$\phi_q(B) = 1 - \phi_1 - \phi_2 B^2 - ... - \phi_q B^q, \quad (3)$$

where $\phi_1 ... \phi_p$ are AR parameters, $\theta_1 \ldots \theta_q$ are MA parameters.

ARIMA model development consists of a three-stage iterative process, which consists of identification, model parameters estimation and diagnostic checking of the residuals of the fitted model (Brockwell and Davis 1991). In the process of identification, the first step is to determine whether the time series is stationary or not stationary. If the series indicates non-stationarity, the time series is first converted to a stationary series by appropriate transformative and differencing operations. Augmented Dickey-Fuller (ADF) tests were performed to test for stationarity (Doornik and Hendry 1994). The ADF regression is given as follows:

$$\Delta\log N_t = \alpha + \delta t + \beta \log N_{t-1} + \sum_{i-1}^{k} \phi_i \Delta \log N_t + \mu_t \quad (4)$$

Where t is the deterministic time trend, log N_t represents the logarithm of study time series at time t, Δlog N_t is the lagged change in study series, μ_t is the error term and α, β and δ are the parameters to be estimated. ADF null hypothesis, H_o: $\rho = 0$ vs. alternative hypothesis $H_o: \rho < 0$ was tested. Failure to reject the null hypothesis is evidence that the series is non-stationary.

At the identification stage, the appropriate AR and MA parameters are found by examining autocorrelation function (ACF) and partial autocorrelation function (PACF) of the time series. Autocorrelation and partial autocorrelation analyses were conducted on the stationary time series. Autocorrelation measures the unconditional relationship of values between time lags, while partial autocorrelation measures the conditional relationship between series observations. Based on the characteristics of ACF and PACF, a variety of possible ARIMA models was established for motorcycle-related and non-motorcycle-related series (accident, fatalities and casualties) in the first stage and then estimated in the second stage.

In contrast to the ARIMA model, which describes the behaviour of single time series, a transfer function model can represent more complex systems that are able to connect one series not only with its own past values but also with past and present values of other, related time series. This approach has already been tested and has proved useful in modelling the traffic accident (Reinfurt *et al*. 1991, Rock 1994, 1996, Scuffham and Langley 2002).

In the ARIMA model with transfer function, the pre-whitening filter is applied to relate the input series and output series. The pre-whitening process eliminates autocorrelation of individual time series, which often produces a spurious correlation in the cross-correlation analysis (Rastetter 1987, Tsai and Chai 1992). The cross correlations between these two pre-whitened series provide information for the identification of the form of the transfer function model between the input series and the

output series. The transfer function model has been used in identifying casual and dynamic relationships between response and explanatory variables in natural phenomena.

In the current study, the ARIMA model with transfer function was applied to evaluate the impact of the MSP and economy recession that changed the trend of motorcycle-related accidents, injuries and fatalities. The MSP intervention was used as a step function (transfer function with binary input series), while GDP was introduced as a transfer function in the models. The general form of the transfer function ARIMA model is presented below.

$$Y_t = v_1(B)x_{1t} + v_2(B)x_{2t} + N_t \qquad (5)$$

where N_t represents the error component of the time series that is specified as a stationary ARIMA model, x_{it} is the explanatory variable (x_{it} represents GDP time series and x_{2t} represents MSP time series), v_1(B) and v_2(B) are the transfer function and B is the delay parameter. The transfer function can be written as:

$$v(B) = \frac{\omega(B)B^b}{\delta(B)} \qquad (6)$$

where the numerator can be expanded to $\omega(B) = (\omega_0 - \omega_1 B - \ldots \omega_s B^s)$, the denominator can be expanded to $\delta(B) = (1 - \delta_1 B - \ldots - \delta_\gamma B^\gamma)$, 's', 'r' and b represent the orders of the polynomials and the degree of seasonality, respectively . Combining equation (1) and (5) yields:

$$Y_t = \frac{\omega_1(B)B^b}{\delta_1(B)}x_{1t} + \frac{\omega_2(B)B^b}{\delta_2(B)}x_{2t} + \frac{\theta(B)}{\phi(B)}a_t \qquad (7)$$

The identification of a transfer function ARIMA model was accomplished by calculating the sample cross correlation function (r_{xy}(k)) at various lags, k, and then comparing it to theoretical impulse response functions of different orders in order to obtain some idea of the delay parameter b and the orders r and s of the operators in the transfer function between an output and an input series. In the modelling effort presented in this paper, the model error term was estimated using the least square estimation method (Marquardt 1963, Box and Jenkins 1976), in which the least square function is calculated via non-linear least-squares iterations.

After a model had been identified and estimated, a diagnostic check is needed to determine the best model among the tentative adequate models. A number of criteria for model comparisons have been proposed. The diagnostic tools used included the statistical significance of the parameters, the Box-Ljung (Q) statistic and the Akaike information criterion (AIC) (Akaike 1974). The Q statistic (Ljung and Box 1979) is defined as:

$$Q = n(n+2)\sum_{i=1}^{k}(n-i)^{-1}r_i^2 \qquad (8)$$

where r_i is the residual autocorrelation at lag i and n is the number of observations used to estimate the model. The Q statistic follows approximately a chi-square distribution with (k-m) degrees of freedom, where m is the number of model parameters. The best model should have the lowest AIC value, a statistically insignificant Q statistic at a lag of about one-quarter of the sample size. After carrying out the complete identification, estimation and diagnostic iterative scheme of Box–Jenkins, the final transfer function ARIMA model can be used for predictions of future road accidents and an estimation of the MSP and economic recession effect.

3. Results

3.1. *Descriptive statistics*

During the 11-year period from 1991 to 2001, 322 698 motorcycle-related accidents were reported to the

Table 1. Motorcycle-related accidents, casualties and fatalities

Year	Fatality	Accident	Casualty
1991	2307	14023	13928
1992	2416	19394	19541
1993	2946	23179	23280
1994	3362	28840	28595
1995	3778	31229	30594
1996	3760	32632	32200
1997	3409	34593	34908
1998	3621	32238	35038
1999	3561	37121	32539
2000	3412	33651	30132
2001	3034	35798	25586

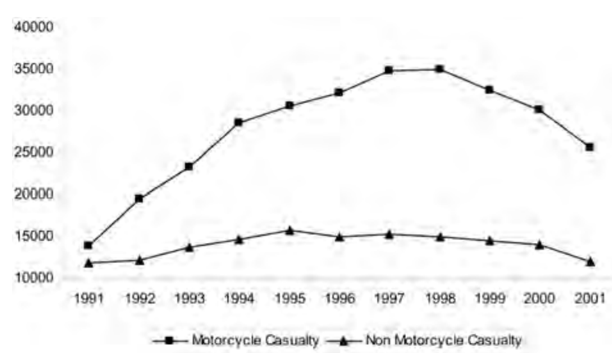

Figure 3. Motorcycle-related and non-motorcycle-related casualties, 1991–2001.

Malaysia Traffic Police. Table 1 displays the distribution of motorcycle-related accidents, casualties and fatalities over the period of 11 years. Figures 3, 4 and 5 show the motorcycle-related and non-motorcycle-related accidents, casualties and fatalities respectively, for the period 1991 – 2001. Figure 3 shows a significant drop in the number of motorcycle casualties, compared with other casualties, since 1998, while figure 4 shows that motorcycle and non-motorcycle-related accidents have increased over the years, but motorcycle-related accidents have escalated sharply compared with non-

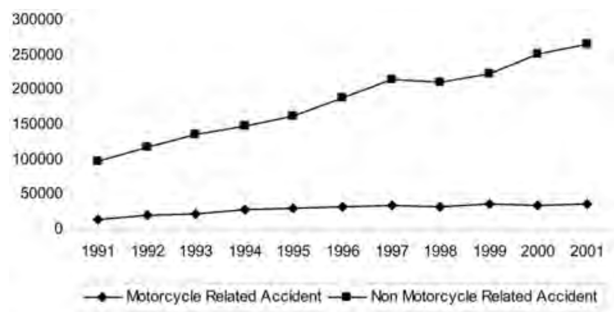

Figure 4. Motorcycle-related and non-motorcycle-related accidents, 1991 – 2001.

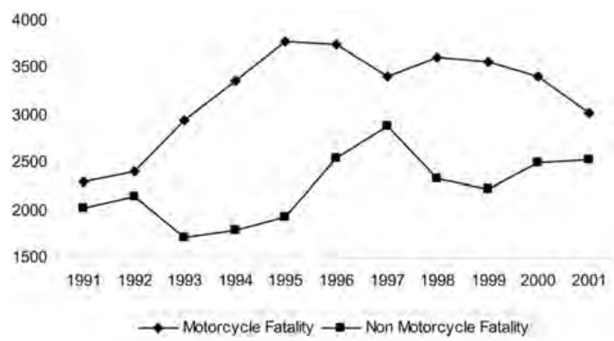

Figure 5. Motorcycle-related fatalities and non-motorcycle-related fatalities, 1991 – 2001.

Table 2. Augmented Dickey-Fuller (ADF) test of the outcome and comparison series in level form

Variable	ADF statistic	5% Critical value
Motorcycle accidents	– 1.323	– 3.41
Motorcycle fatalities	– 1.542	– 3.41
Motorcycle casualties	– 1.725	– 3.41
Non-motorcycle accidents	– 1.622	– 3.41
Non-motorcycle fatalities	– 1.742	– 3.41
Non-motorcycle casualties	– 1.892	– 3.41

Table 3. Augmented Dickey-Fuller (ADF) test of the outcome and comparison series in logarithm form

Variable	ADF statistic	5% Critical value
Motorcycle accidents	– 5.323	– 2.86
Motorcycle fatalities	– 4.242	– 2.86
Motorcycle casualties	– 4.723	– 2.86
Non-motorcycle accidents	– 3.432	– 2.86
Non-motorcycle fatalities	– 3.541	– 2.86
Non-motorcycle casualties	– 3.532	– 2.86

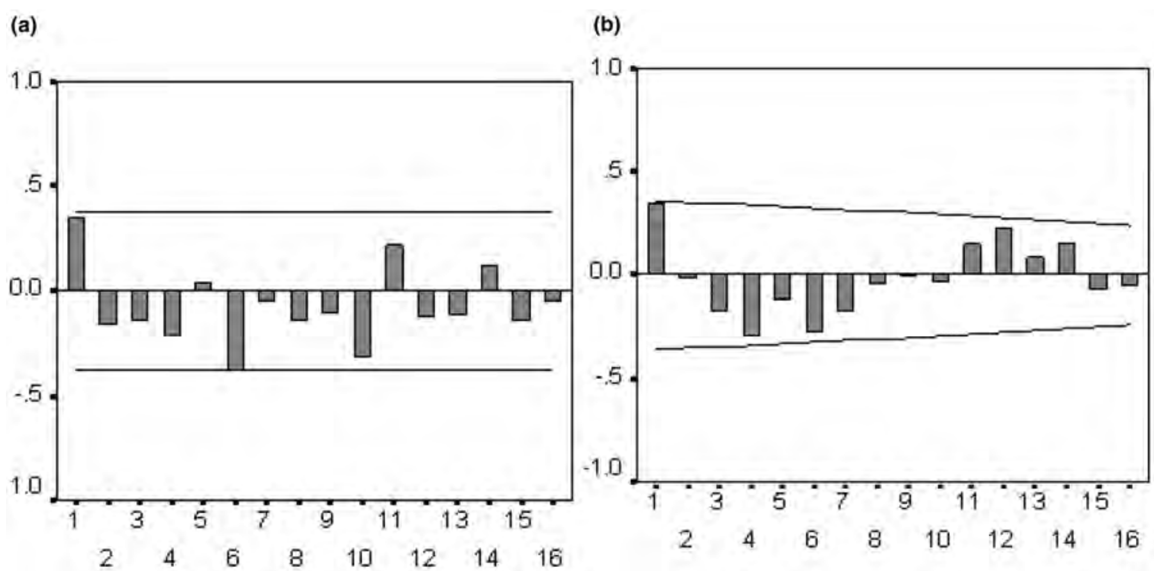

Figure 6. Autocorrelation (a) and partial autocorrelation (b) functions of motorcycle-related accidents.

motorcycle-related accidents. In figure 5, the motorcycle fatalities curve shows a decreasing trend after the implementation of the safety programme. On the other hand, a similar trend has not been observed in non-motorcycle-related fatalities.

Since the safety programme was implemented in 1998, these figures have suggested that it has effectively reduced motorcycle-related accidents, casualties and fatalities. The following section will explain the ARIMA model with transfer function in determining the effectiveness of the MSP in alleviating motorcycle-related accidents, casualties and fatalities.

3.2. *Augmented Dickey-Fuller test*

Tables 2 and 3 present the results of the ADF test of the logarithm of motorcycle- and non-motorcycle-related accidents, fatalities and casualties. This test is applied in a level trend, followed by the same test in the logarithm transformation form. The ADF test statistic is compared with the critical values from the Dickey-Fuller distribution with a trend at the 5% significance level. Since the ADF statistics for all outcome series and comparison series are less than the critical value of -3.41, the null hypothesis of ADF is not rejected, implying that the series are not

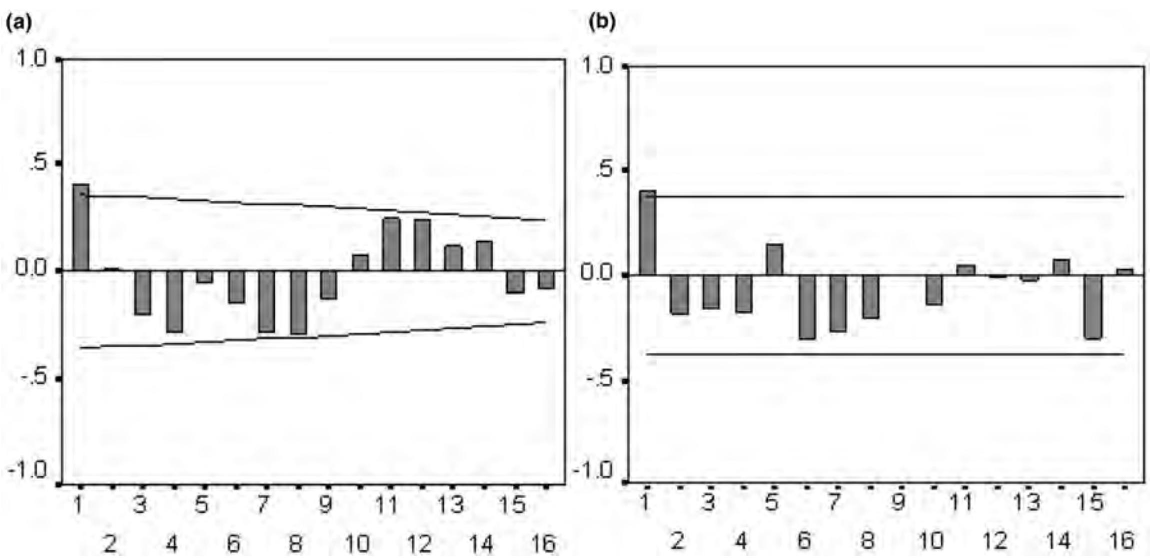

Figure 7. Autocorrelation (a) and partial autocorrelation (b) functions of motorcycle-related casualties.

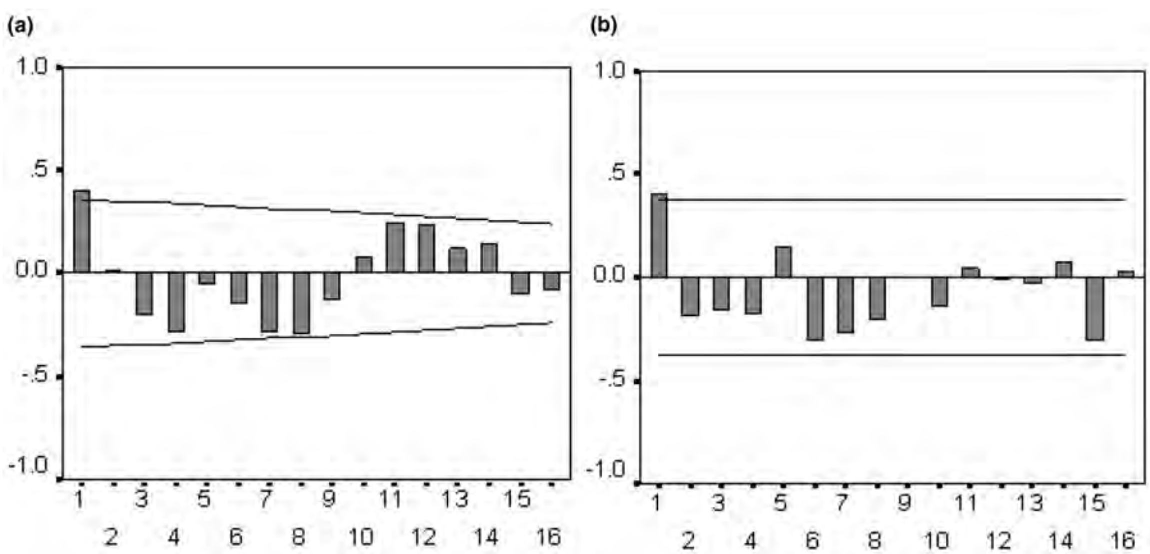

Figure 8. Autocorrelation (a) and partial autocorrelation (b) functions of motorcycle-related fatalities.

stationary. By taking the logarithm transformation for all series, the series re-transformed into a stationary series, as shown in table 3, with the ADF statistic for the series being more than the critical value of -2.86. Thus, the null hypothesis of the ADF test is rejected; the logarithm transformed series is stationary.

3.3. *Univariate autocorrelation integrated moving average analysis*

ARIMA models were run on a yearly time series of accidents, casualties and fatalities for motorcycle- and non-motorcycle-related cases. From the plots in figure 6, the partial autocorrelation function of the motorcycle-related accidents appears to be dying down exponentially, while the autocorrelation function cuts off to zero after lag 6, thus suggesting a MA(6) model. The ACF and PACF of the non-motorcycle-related accident, non-motorcycle-related fatality, motorcycle-related fatality and motorcycle-related casualty are fairly similar (figures 7 to 10). For the ACF and PACF, there was significant correlation at lag 1 and coefficients were cut off after lag 1. This suggests a MA(1) and AR(1) model. Figure 11 shows ACF and PACF for the non-motorcycle casualties. It can be observed that there is a

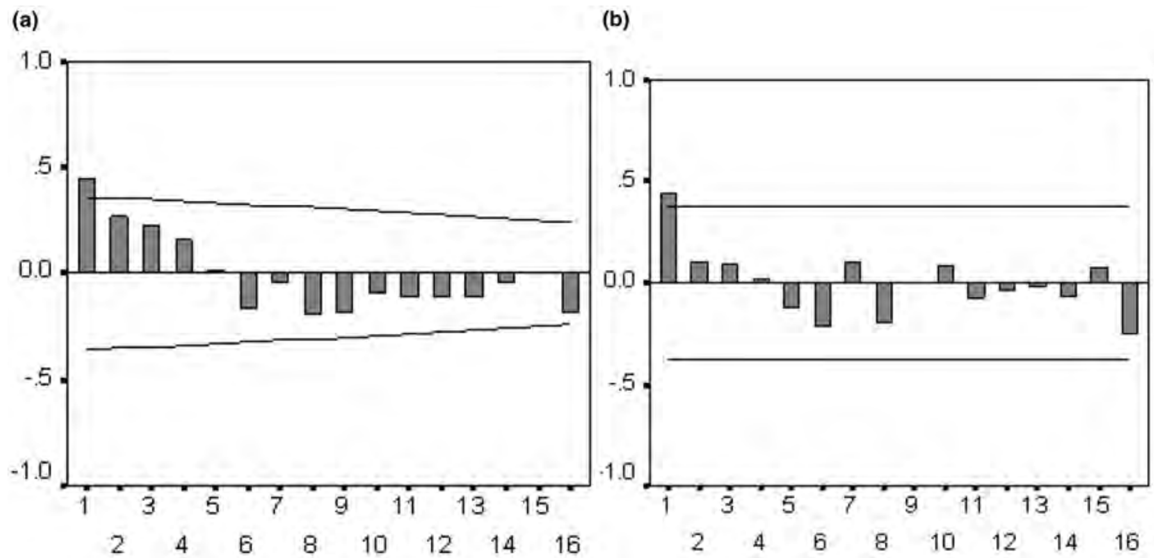

Figure 9. Autocorrelation (a) and partial autocorrelation (b) functions of non-motorcycle-related accidents.

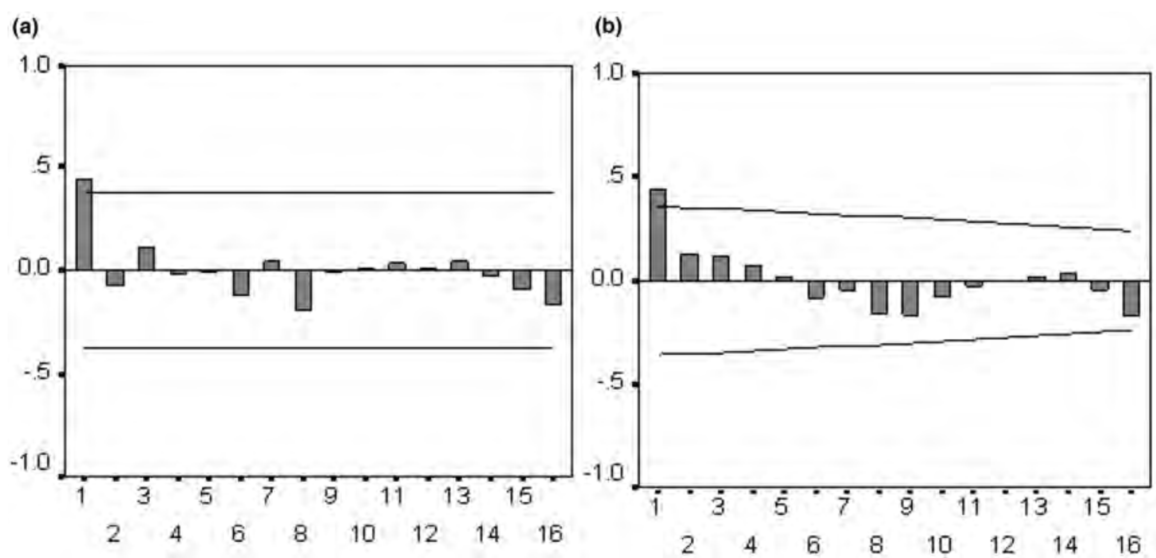

Figure 10. Autocorrelation (a) and partial autocorrelation (b) functions of non-motorcycle-related fatalities.

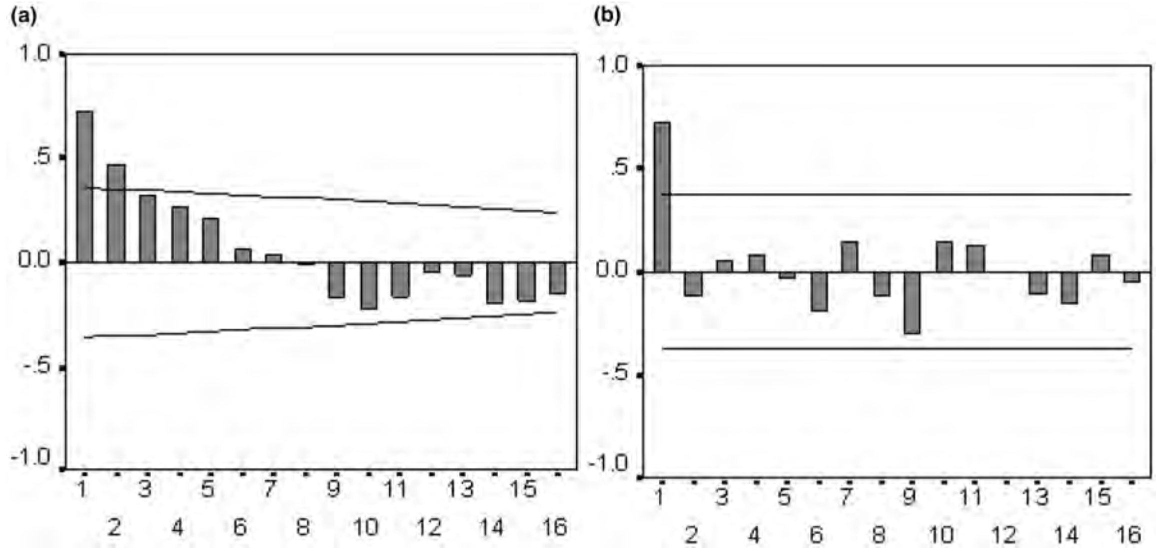

Figure 11. Autocorrelation (a) and partial autocorrelation (b) functions of non-motorcycle-related casualties.

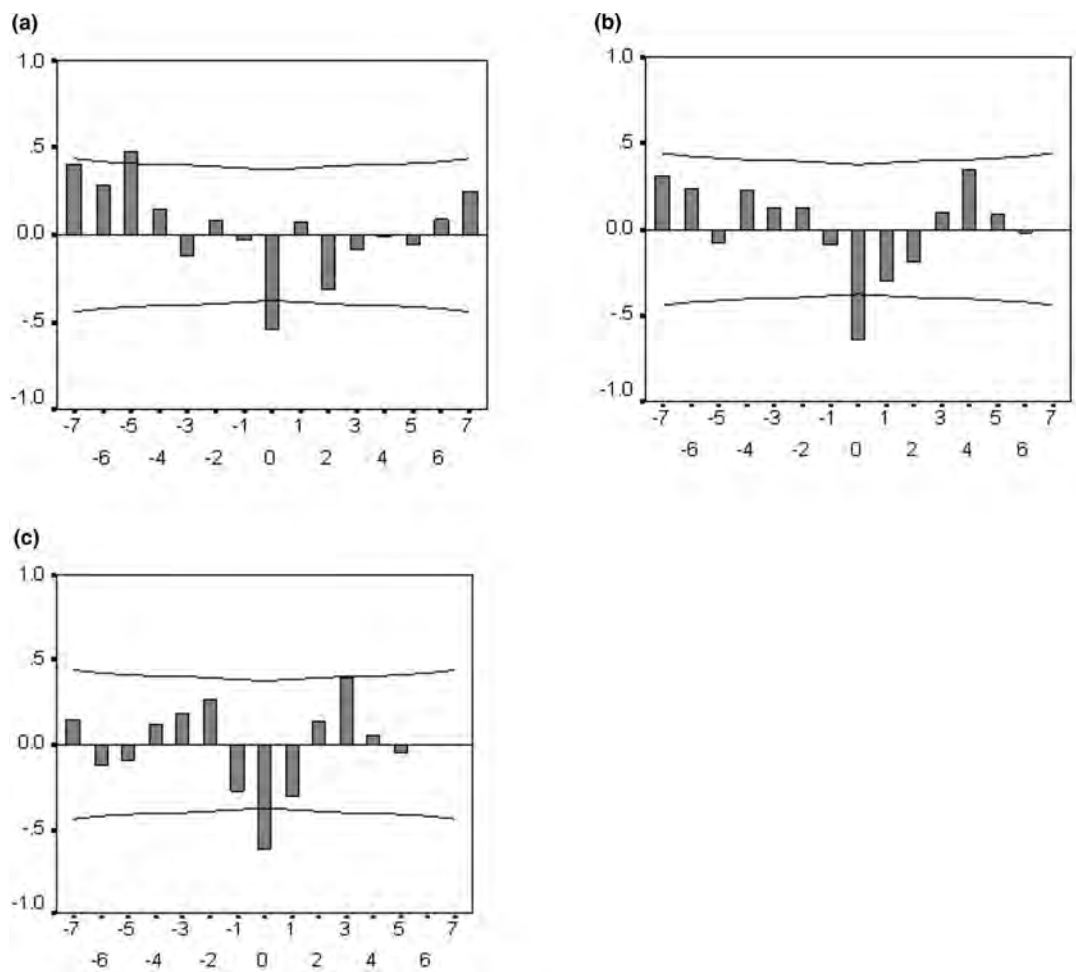

Figure 12. Cross-correlation functions of the pre-whitening time series between Motorcycle Safety Programme (MSP) and outcome series (between MSP and motorcycle-related accidents (a), between MSP and motorcycle-related casualties (b) and between MSP and motorcycle-related fatalities (c)).

pattern of exponential decay in the ACF plot, while the PACF at lag 1 is significantly different from zero. The pattern observed in figure 11 is quite similar to the theoretical patterns of ACF and PACF of a MA process of the order 2, thus suggesting a MA(2).

3.4. *Transfer function analysis*

Transfer function analysis is used to generate the impulse response of GDP and MSP to unit changes in the input indicator series (outcome and comparison time series). Using the AR and MA factors calculated in the previous section, GDP and MSP are pre-whitened with the input indicator series (outcome and comparison series). The cross-correlation functions of the pre-whitened time series are shown in figures 12 to 15. Outcome time series (motorcycle-related accident, motorcycle-related casualty and motorcycle-related fatality) was significantly negatively correlated with MSP only at lag 0 (figure 12). However, there was no significant correlation between comparison time series and MSP time series (figure 13). The cross-correlation plot between input indicator series (outcome and comparison series) and GDP shows a similar trend (figures 14 and 15). It can be observed that input indicator series were significantly positively correlated with GDP time series at lag 0.

Based on the above ACF and PACF observation, the ARIMA models with transfer function are established as follows:

For non-motorcycle-related accidents the model is:

$$(1 - 0.2315B)N_t = 0.00043x_{1t} + (1 - 0.4373B)a_1 \qquad (9)$$

$$(0.010) \qquad (0.077) \qquad (0.033)$$

For non-motorcycle-related casualties the model is:

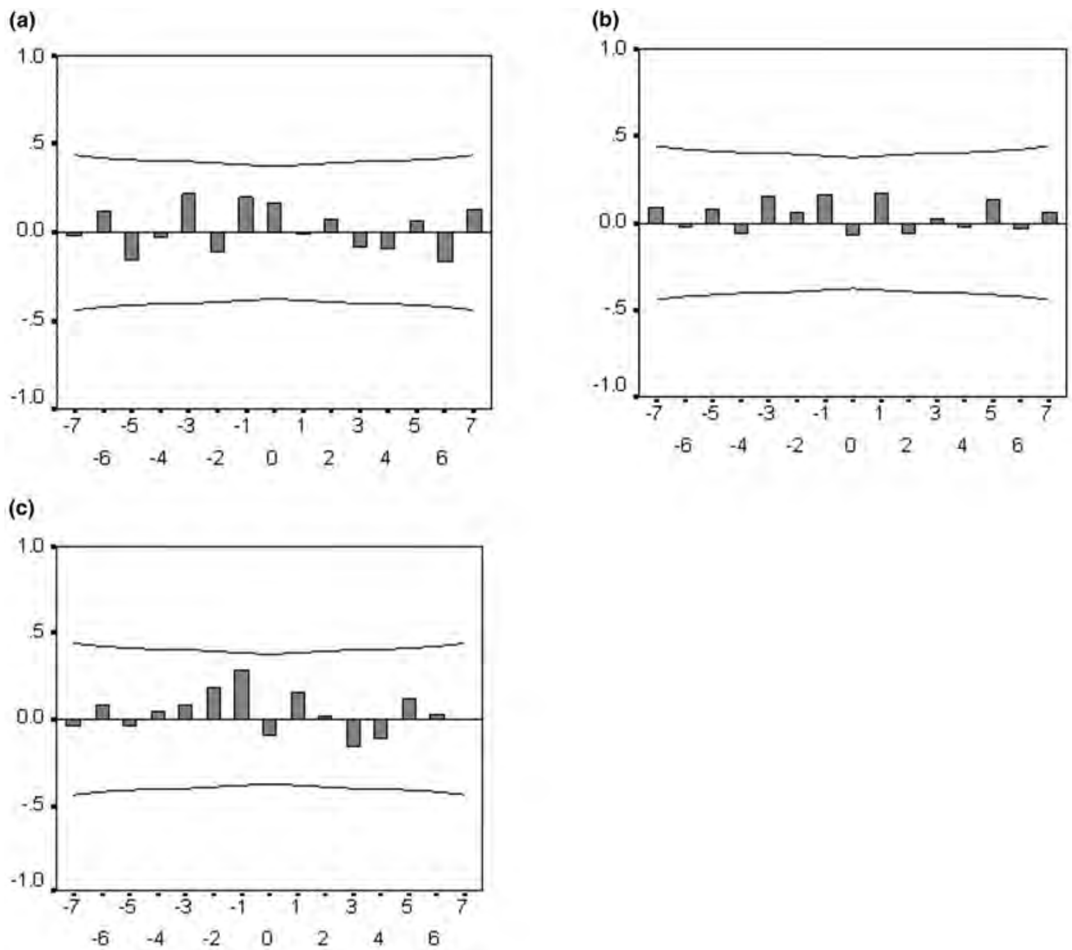

Figure 13. Cross-correlation functions of the pre-whitening time series between Motorcycle Safety Programme (MSP) and comparison series (between MSP and non-motorcycle-related accidents (a), between MSP and non-motorcycle-related casualties (b) and between MSP and non-motorcycle-related fatalities (c)).

$$N_t = 0.00033x_{1t} + (1 - 0.2136B - 0.1135B^2)a_t \qquad (10)$$
$$(0.021) \qquad (0.017) \qquad (0.068)$$

For non-motorcycle-related fatalities the model is:

$$(1 - 0.2315B)N_t = 0.00012x_{1t} + (1 - 0.4373B)a_1 \qquad (11)$$
$$(0.022) \qquad (0.020) \qquad (0.063)$$

For motorcycle-related accidents the model is:

$$N_t = 0.00032x_{1t} - 0.29x_{2t} + (1 - 0.1373B - 0.4211B^2 - 0.3222B^2 - 0.2321B^6)a_t$$
$$(0.032) \qquad (0.042) \qquad (0.036) \qquad (0.040) \qquad (0.036) \qquad (0.022) \qquad (12)$$

For motorcycle-related casualties the model is:

$$(1 - 0.656B)N_t = 0.00021x_{1t} - 0.32x_{2t} + (1 - 0.211B)a_t$$
$$(0.041) \qquad (0.061) \qquad (0.036) \qquad (0.059) \qquad (13)$$

For motorcycle-related fatalities the model is:

$$(1 - 0.4183B)N_t = 0.00013x_{1t} - 0.48x_{2t} + (1 - 0.2914B)a_t \qquad (14)$$
$$(0.037) \qquad (0.066) \qquad (0.051) \qquad (0.075)$$

The actual p value for all model coefficients as shown in the equations is less than 0.1 level of significance. The model fitting results are presented in table 4. The MSP intervention coefficient has negative value for motorcycle-related accidents, casualties and fatalities, which clearly indicates a reduction in motorcycle-related accidents, casualties and fatalities after the implementation of the MSP. Furthermore, the implementation of MSP has resulted in a 25%, 27% and 38% reduction in the number of motorcycle-related accidents, casualties and fatalities, respectively. The GDP coefficients show positive value for outcome and comparison series, which implies that the number of motorcycle-related and also non-motorcycle-related acci-

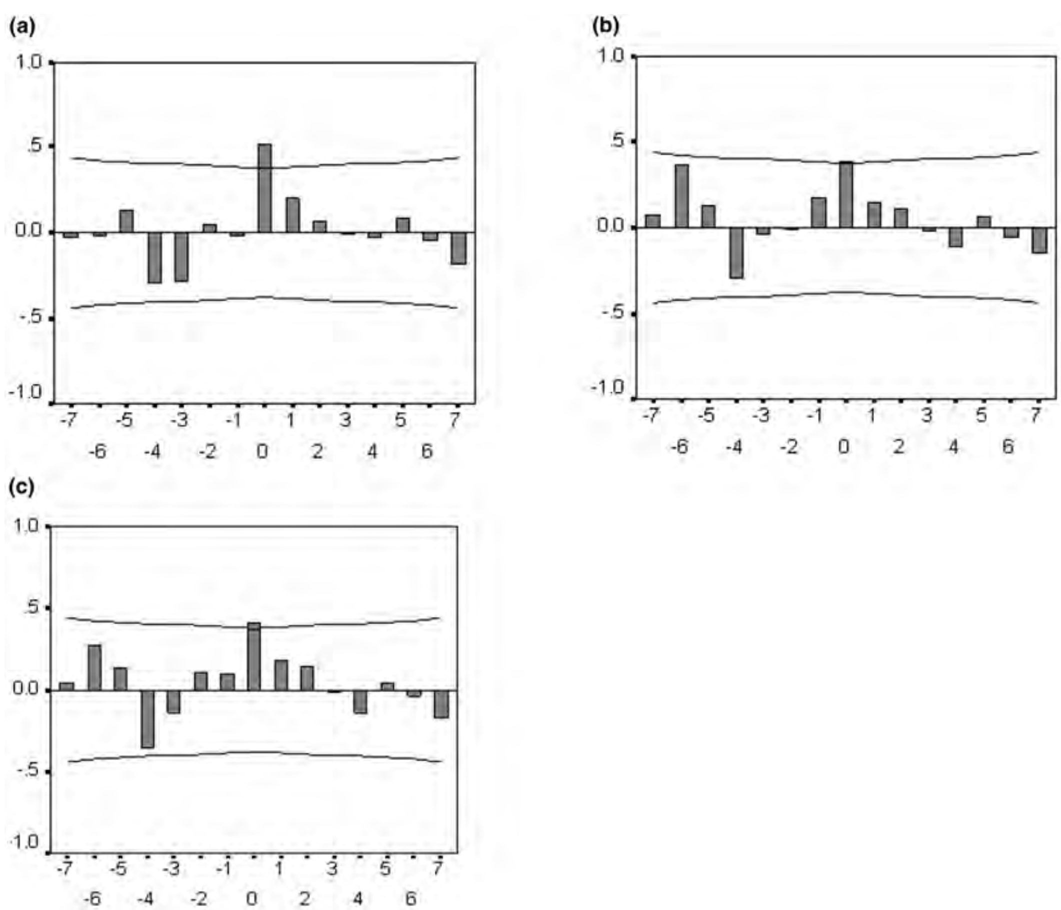

Figure 14. Cross-correlation functions of the pre-whitening time series between gross domestic product (GDP) and outcome series (between GDP and motorcycle-related accidents (a), between GDP and motorcycle-related casualties (b) and between GDP and motorcycle-related fatalities (c)).

dents, casualties and fatalities follows economy performance.

3.5. *Diagnostic checking*

Once ARIMA models are fitted, it is important to investigate how well the model fits the given time series. This comprises the step of diagnostic checking in model building. The Q statistic and the AIC are useful in this regard. The diagnostic results are summarized in table 4. The computed Q *p* values for all ARIMA models are higher than 0.1 level of significance. Thus, the null hypothesis, that the residual autocorrelations are independent, cannot be rejected. Hence, it may be inferred that the residual autocorrelations are not significantly different from zero. The Box-Ljung analysis implies that the models are adequate. This is further enhanced by the lowest AIC value for all ARIMA models.

4. Discussion

The MSP has proven to be successful in bringing down the number of motorcycle-related accidents, casualties and fatalities. The analysis revealed approximately a 25% reduction in the number of motorcycle accidents, with a 27% and 38% drop in the rate of motorcycle casualties and motorcycle fatalities, respectively. This finding supports Radin Umar and Law's (1999) earlier analysis that the MSP was effective in improving overall traffic fatalities and casualties in Malaysia.

In a separate study, Ahmad *et al.* (1999) found that the MSP has significantly improved riders' perception and understanding of the safety issues highlighted in the campaign. Furthermore, Radin Umar (1999) observed that proper compliance with helmet strapping has increased significantly, from about 41% in the before period to 66% in the after period.

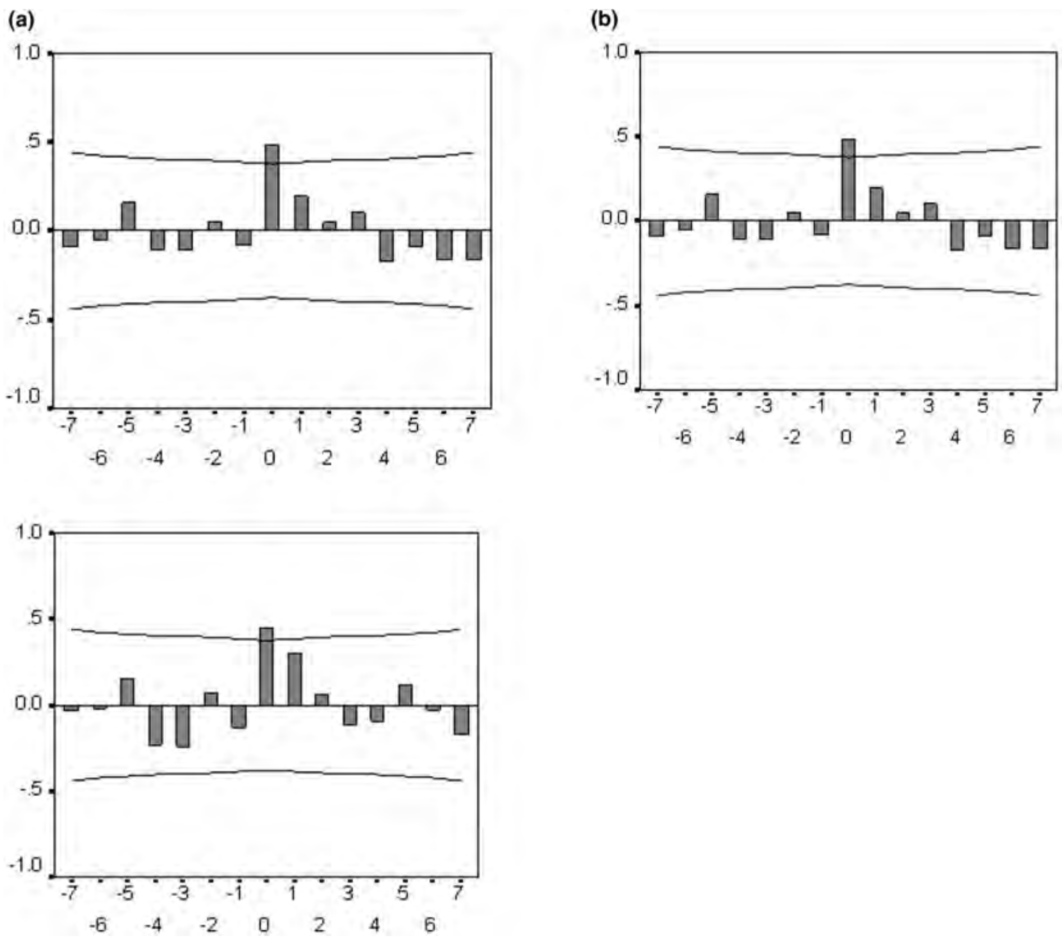

Figure 15. Cross-correlation functions of the pre-whitening time series between gross domestic product (GDP) and comparison series (between GDP and non-motorcycle-related accidents (a), between GDP and non-motorcycle-related casualties (b) and between GDP and non motorcycle-related fatalities (c)).

Table 4. Results of the autocorrelation integrated moving average model with transfer function

Variable	Category	Motorcycle safety programme coefficient	Gross domestic product coefficient	% change	Box-Ljung (Q) *p* value
Accident	Motorcycle	−0.29	0.00032	25.2	0.23
	Non-motorcycle	NS	0.00043	NS	0.17
Casualty	Motorcycle	−0.32	0.00021	27.4	0.36
	Non-motorcycle	NS	0.00033	NS	0.21
Fatality	Motorcycle	−0.48	0.00013	38.1	0.44
	Non-motorcycle	NS	0.00012	NS	0.27

Significance level < 0.1; NS = not statistically significant.

Implementation of the MSP, however, is not the sole factor behind the declining numbers of traffic fatalities. The economic slowdown has somewhat significantly played a controlling factor. As hypothesized, the total number of motorcycle-related accidents, casualties and fatalities is positively related to GDP. This finding indicates that the relationship between GDP and accident-related cases is closely associated with economic activities and, hence, traffic exposures.

By introducing this economic performance indicator into the analysis, the effects that economic recession may have on the incidence of motorcycle-related accidents, casualties and fatalities are controlled. Thus, the ARIMA model with transfer function provides a clearer picture as to how MSP has affected motorcycle safety in Malaysia.

5. Conclusion

Based on the above analysis, it can be concluded that the MSP has been one of the effective measures in reducing motorcycle safety problems in Malaysia. Apart from that, performance of the country's economy was also found to be significant in explaining the number of accidents, casualties and fatalities in Malaysia.

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